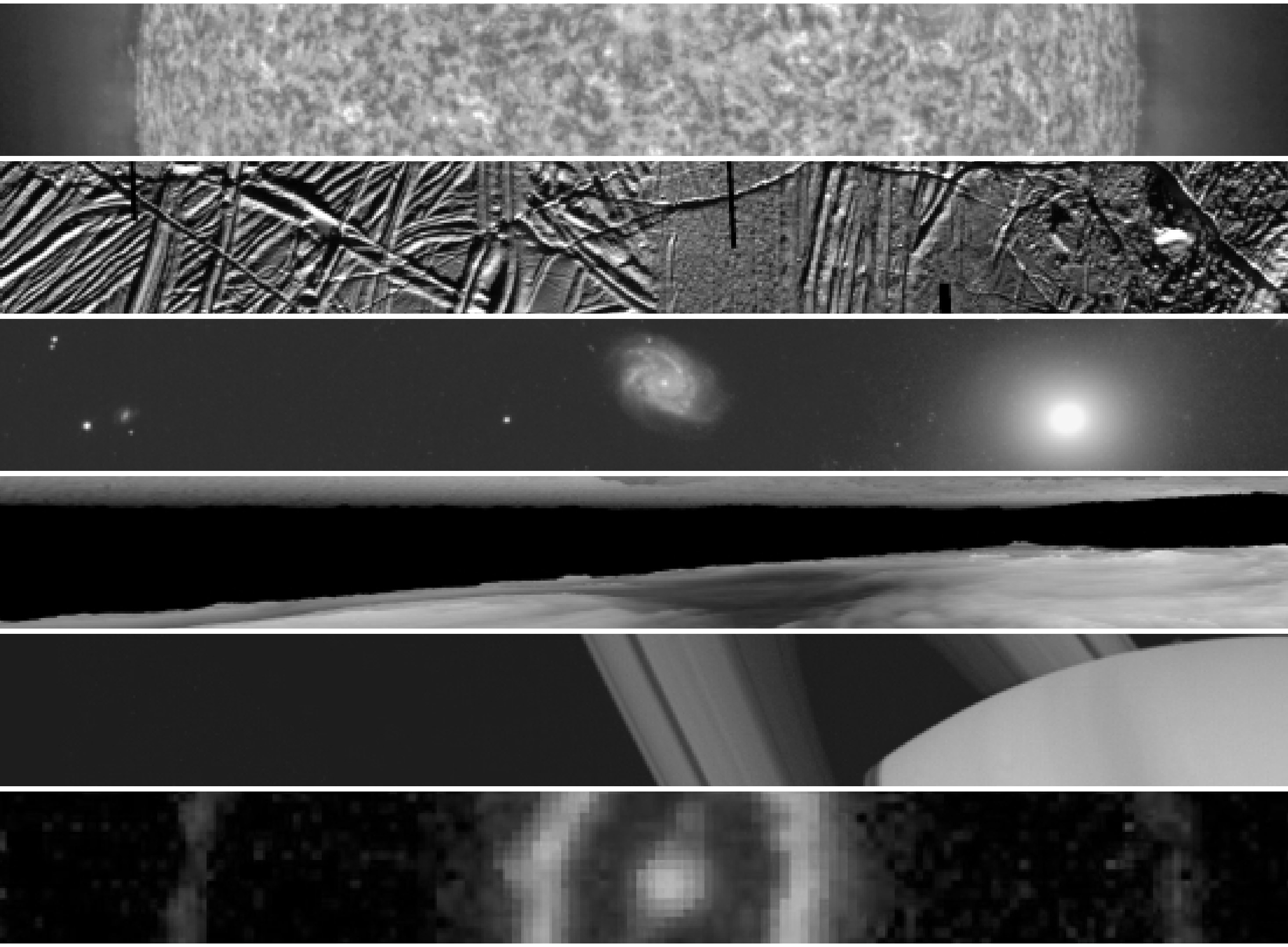
Space-Based Astronomy

AN EDUCATOR GUIDE WITH ACTIVITIES FOR SCIENCE, MATHEMATICS, AND TECHNOLOGY EDUCATION



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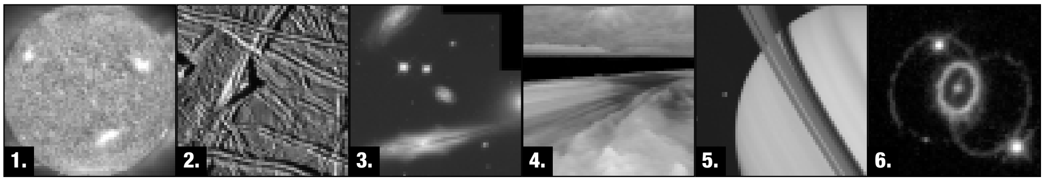
About the Cover Images



1. EIT 304Å image captures a sweeping prominence—huge clouds of relatively cool dense plasma suspended in the Sun's hot, thin corona. At times, they can erupt, escaping the Sun's atmosphere. Emission in this spectral line shows the upper chromosphere at a temperature of about 60,000 degrees K. *Source/Credits: Solar & Heliospheric Observatory (SOHO). SOHO is a project of international cooperation between ESA and NASA.*
2. This mosaic shows some of the highest resolution images obtained by the Solid State Imaging (SSI) system on NASA's Galileo spacecraft during its eleventh orbit around Jupiter. The sun illuminates the scene from the left, showing hundreds of ridges that cut across each other, indicating multiple episodes of ridge formation either by volcanic or tectonic activity within the ice. *The Jet Propulsion Laboratory, Pasadena, CA, manages the mission for NASA's Office of Space Science, Washington, DC. JPL is a division of California Institute of Technology.*
3. A Minuet of Galaxies: This troupe of four galaxies, known as Hickson Compact Group 87 (HCG 87), is performing an intricate dance orchestrated by the mutual gravitational forces acting between them. The dance is a slow, graceful minuet, occurring over a time span of hundreds of millions of years. *Image Credit: Hubble Heritage Team (AURA/ STScI/ NASA).*
4. Frames from a three dimensional visualization of Jupiter's equatorial region. These features are holes in the bright, reflective, equatorial cloud layer where warmer thermal emission from Jupiter's deep atmosphere can pass through. The circulation patterns observed here along with the composition measurements from the Galileo Probe suggest that dry air may be converging and sinking over these regions, maintaining their cloud-free appearance. *The Jet Propulsion Laboratory, Pasadena, CA, manages the Galileo mission for NASA's Office of Space Science, Washington, DC. JPL is an operating division of California Institute of Technology.*
5. This image of the planet Saturn and natural satellites Tethys and Dione was taken on January 29, 1996, by Voyager 1.
6. This striking NASA Hubble Space Telescope picture shows three rings of glowing gas encircling the site of supernova 1987A, a star which exploded in February 1987. The supernova is 169,000 light years away, and lies in the dwarf galaxy called the Large Magellanic Cloud, which can be seen from the southern hemisphere. *Credit: Dr. Christopher Burrows, ESA/STScI and NASA.*

To find out more about these images and projects, please visit *http://spacescience.nasa.gov*

ACKNOWLEDGMENTS

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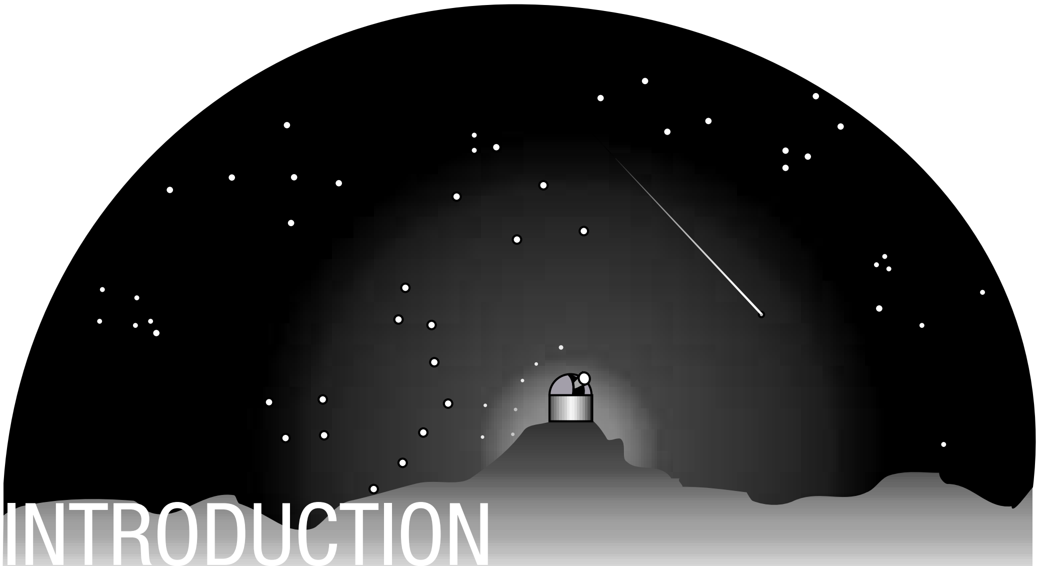


INTRODUCTION

If you go to the country, far from city lights, you can see about 3,000 stars on a clear night. If your eyes were bigger, you could see many more stars. With a pair of binoculars, an optical device that effectively enlarges the pupil of your eye by about 30 times, the number of stars you can see increases to the tens of thousands. With a medium-sized telescope with a light-collecting mirror 30 centimeters in diameter, you can see hundreds of thousands of stars. With a large observatory telescope, millions of stars become visible.

It would seem that when it comes to observing the universe, the larger the instrument, the better. This is true up to a point, but there are limits—limits not imposed by technology but by nature itself.

Surrounding Earth is a life-sustaining atmosphere that stands between our eyes and the radiation that falls upon Earth from outer space. This radiation is comprised of a very broad spectrum of energies and wavelengths. Collectively, they are referred to as the electromagnetic spectrum. They range from radio and microwave radiation on the low energy (long wavelength) end through infrared, visible, ultraviolet, and x-rays to gamma rays on the high energy (short wavelength) end. Gases and other components of our atmosphere distort, filter, and block most of this radiation permitting only a partial picture, primarily visible radiation and some radio waves, to reach Earth's surface. Although many things can be learned about our universe by studying it from the surface of Earth, the story is incomplete. To view celestial objects over the whole range of the electromagnetic spectrum, it is essential to climb above the atmosphere into outer space.

From its earliest days, the National Aeronautics and Space Administration (NASA) has used the emerging technology of rockets to explore the universe. By lofting telescopes and other scientific instruments above the veil of Earth's atmosphere, NASA has delivered a treasure house of information to astronomers, leading them to rethink their most fundamental ideas about what the universe is, how it came to be, how it functions, and what it is likely to become.

HOW TO USE THIS GUIDE

This curriculum guide uses hands-on activities to help students and teachers understand the significance of space-based astronomy—astronomical observations made from outer space. It is not intended to serve as a curriculum. Instead, teachers should select activities from this guide that support and extend existing study. The guide contains few of the traditional activities found in many astronomy guides such as constellation studies, lunar phases, and planetary orbits. It tells, rather, the story of why it is important to observe celestial objects from outer space and how to study the entire electromagnetic spectrum. Teachers are encouraged to adapt these activities for the particular needs of their students. When selected activities from this guide are used in conjunction with traditional astronomy curricula, students benefit from a more complete experience.

The guide begins with a survey of astronomy-related spacecraft NASA has sent into outer space. This is followed by a collection of activities organized into four units: The Atmospheric Filter, The Electromagnetic Spectrum, Collecting Electromagnetic Radiation, and Down to Earth. A curriculum matrix identifies the curriculum areas each activity addresses. Following the activities is information for obtaining a 35 mm slide set with descriptions showing current results from NASA spacecraft such as the Hubble Space Telescope (HST), Compton Gamma Ray Observatory (CGRO), and the Cosmic Background Explorer (COBE). The guide concludes with a glossary, a reference list, a NASA Resources list, and an evaluation card. Feedback from users of this guide is essential for the development of future editions and other classroom supplementary materials.

THE SPACE AGE BEGINS

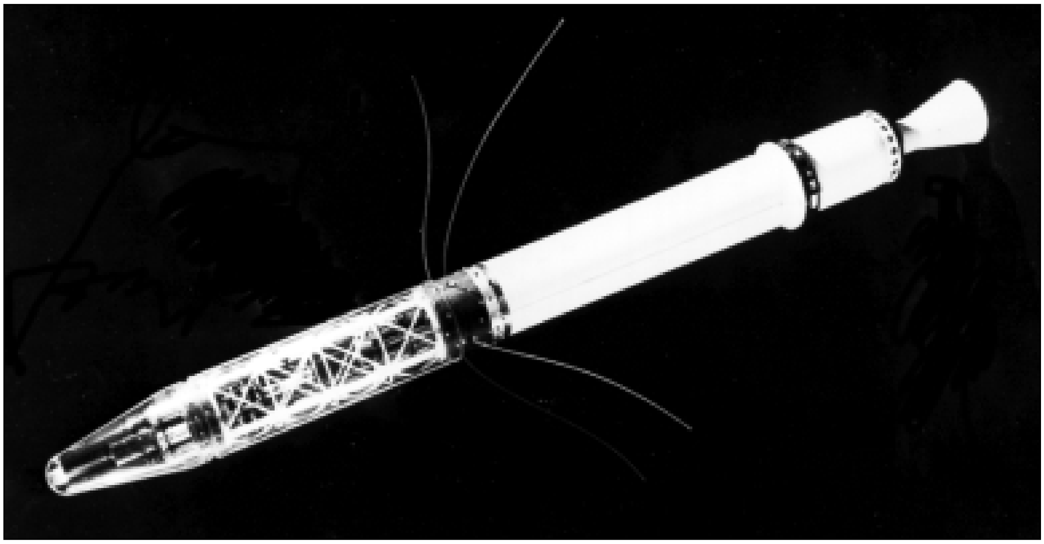
Within months of each other, the United States and the Soviet Union launched their first artificial satellites into orbit around Earth. Both satellites were small and simple. Sputnik 1, a Soviet spacecraft, was the first to reach orbit. It was a 58-centimeter-diameter aluminum sphere that carried two radio transmitters, powered by chemical batteries. The satellite reached orbit on October 4, 1957. Although an extremely primitive satellite by today's standards, Sputnik 1 nevertheless enabled scientists to learn about Earth's magnetic field, temperatures in space, and the limits of Earth's atmosphere.

A much larger Sputnik 2 followed, carrying a small dog as a passenger. Although primarily investigating the response of living things to prolonged periods of microgravity, Sputnik 2 did sense the presence of a belt of high-energy charged particles trapped by Earth's magnetic field. Explorer 1, the United States' first satellite, defined that field further.

The cylindrical, 13.6 kilogram Explorer 1 rode to space on top of a Juno I rocket on January 31, 1958. It was launched by the United States Army in association with the National Academy of Sciences and the Jet Propulsion Laboratory of the California Institute of Technology. NASA was not created formally by an act of Congress until the following October.

Explorer 1 carried scientific instruments designed by Dr. James Van Allen of the University of Iowa. Circling Earth in an orbit ranging from 360 to 2,531 kilometers, the satellite radioed back radiation measurements, revealing a deep zone of radiation surrounding Earth.

Born of the technology of World War II and the tensions of the Cold War, the space age began in



Artist's concept of *Explorer 1* in space

the peaceful pursuit of scientific discovery. In the more than 35 years that have followed, thousands of spacecraft have been launched into Earth orbit, to the Moon, and to the planets. For the majority of those spacecraft, the goal has been to learn about Earth, our solar system, and the universe.

ASTROPHYSICS

Just a few decades ago, the word astronomy was a general term that described the science of the planets, moons, Sun and stars, and all other heavenly bodies. In other words, astronomy meant the study of anything beyond Earth. Although still an applicable term, modern astronomy, like most other sciences, has been divided and subdivided into many specialties. Disciplines that study the planets include planetary geology and planetary atmospheres. The study of the particles and fields in space is divided into magnetospheric physics, ionospheric physics, and cosmic and heliospheric physics. The Sun has its own solar physics discipline. The origin and evolution of the universe is the subject of cosmology.

Generally, objects beyond our solar system are handled in the field of astrophysics. These include stars, the interstellar medium, other objects in our Milky Way Galaxy, and galaxies beyond our own.

NASA defines astrophysics as the investigation of astronomical bodies by remote sensing from Earth or its vicinity. Because the targets of the astrophysicist are generally beyond human reach even with our fastest rockets, astrophysicists concentrate solely on what the electromagnetic spectrum can tell them about the universe. NASA's astrophysics program has three goals: to understand the origin and fate of the universe; to describe the fundamental laws of physics; and to discover the nature and evolution of galaxies, stars, and the solar system. The investigations of astrophysicists are carried out by instruments aboard free-flying satellites, sounding rockets that penetrate into space for brief periods, high-flying aircraft and high-altitude balloons, and Space Shuttle missions.